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USL SERIES
OPERATING MANUAL

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KRAUTKRAMER-BRANSON, INC.
250 LONG BEACH BLVD.
STRATFORD, CT 06497

CONTENTS

1) Warranty Information

2) Introduction:
   - 2.1 Scope
   - 2.2 Description
   - 2.3 Standard Accessories
   - 2.4 Technical Data

3) Front Panel Controls, Indicators and Connectors

4) Instrument Familiarization:
   - 4.1 Preliminary Control Settings
   - 4.2 Familiarization Procedure

5) Gate Monitor:
   - 5.1 Purpose
   - 5.2 Adjustment Procedure

6) Electronic DAC:
   - 6.1 Purpose
   - 6.2 Adjustment Procedure

7) Digital Readout:
   - 7.1 Purpose
   - 7.2 Adjustment Procedure

8) Automatic Display of Surface (Projection) Distance and Depth for Angle Beam Inspection

9) Thickness and Distance Measurement:
   - 9.1 General Information
   - 9.2 Calibration Procedure:
     - 9.2.1 Single Element Probe
     - 9.2.2 Dual Element Probe
     - 9.2.3 Delay Line Probe

10) Flaw Size Evaluation

11) Angle Beam Examination

Chapter 1

WARRANTY

When used in accordance with the manufacturer's written instructions and under normal operating conditions, KRAUTKRAMER-BRANSON, INCORPORATED (K-B) test instruments are guaranteed to be free from defects in material and workmanship for a period of one (1) year from date of shipment. K-B will repair free of labor and material charges any unit which proves defective within 90 days from date of original shipment by K-B or by an authorized representative or distributor, and during the remainder of the one-year period K-B will replace or repair defective parts or defective workmanship, customer to pay labor charges only.

All repair work will be made F.O.B. Stratford, Connecticut, or at an authorized repair station as advised by K-B, provided the defective unit is returned properly packed with all transportation charges prepaid. Any and all equipment replacement will be at the sole discretion of K-B.

This warranty shall not apply to equipment subjected to misuse or abuse, improper installation, alteration, neglect or accident. Excluded from this warranty coverage are expendable items such as transducers, interconnecting cables, batteries, and vacuum tubes when used in the instrument. Accessory items such as recorders, etc. will be covered under the original manufacturer's warranty as given to K-B.

This warranty is limited to the original purchaser and is not transferrable. No other warranty, either expressed or implied is made.

SERVICE

Should service become necessary, K-B has established a number of authorized Service Centers throughout the United States and Canada. For the location of the nearest facility, contact:

Manager, Customer Service
Krautkramer-Branson, Incorporated
250 Long Beach Blvd., Box 408
Stratford, Connecticut 06497
Telephone: 203/377-3900

Comments or questions concerning this manual should be directed to:

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USL SERIES PORTABLE FLAW DETECTION/ THICKNESS MEASUREMENT INSTRUMENTS

MODELS USL-31, USL-32, USL-36, USL-37, USL-38

SECTION 1

GENERAL INFORMATION

This manual contains information concerning the operation of USL SERIES portable flaw detection/thickness measurement instruments, Models USL-31, USL-32, USL-36, USL-37 and USL-38; manufactured by Krautkramer-Branson, Inc., Stratford, Connecticut. Unless noted or labeled otherwise, all information in this manual applies equally to the different models covered. The units are referred to individually by the appropriate model number and collectively as the instrument.

DESCRIPTION

The instrument is a pulse-echo device capable of detecting, locating and evaluating flaws in a wide variety of materials. It is also used for performing wall thickness measurements from one side of the test material. The Krautkramer-Branson USL-Series described in this manual consists of five different instruments designed to meet individual requirements.

The USL-31 is a basic instrument designed for general testing needs. The USL-32 is identical to the USL-31, except that it includes a flaw gate. The USL-36 includes a flaw gate and Electronic Distance Amplitude Correction. The USL-37 includes a flaw gate and digital readout. The USL-38, the most sophisticated instrument in the series, includes a flaw gate, Electronic Distance Amplitude Correction and digital readout.

Instrument control functions are color-coded in order to provide logical grouping of the controls. Basic control functions are marked in white, gate controls are marked in yellow, Distance Amplitude Correction controls are marked in red and digital readout controls are marked in green.

STANDARD ACCESSORIES

1	USL-345 Charger (with attachment cable for externally charging an extra battery pack)
1	MVS Screen Overlay
1	BBCL-6 Transducer Cable
1	Operating Manual
1	Pocket Blue Book
1	MLS-2 Light Shield
1	NICAD Battery Pack

OPTIONS

1	Lead Acid Battery Pack
1	Service Manual

USL SERIES

Technical Data

Frequency range:	0.5 - 15 MHz
Screen display:	linear display of the echo amplitudes.
Selective/broad band gain:	can be switched from broad band 0.5 - 15 MHz, without smoothing, with single wave rectification (for shock wave probes) to narrow band 2 - 12 MHz or 0.5 - 4 MHz with full wave rectification.
Variable pulse strength:	can be switched from maximum pulse strength to continuously variable damping for the best possible matching to the respective probe and the specific assignment.
100 dB adjusting range:	coarse gain setting 0/20/40/60 dB, fine gain setting 0 - 40 dB, in 2 dB steps, continuously variable fine setting 0-6 dB.
Linear reject:	suppression of the echo amplitudes, adjustable from 0-4/5 of the screen scale height; thereby the amplitude of the unsuppressed echoes remain unaffected.
Testing range:	.5" - 15'; .5", 2.5", 10", 50" (steel) with stepless control (digital control with lock) can be extended from x1 to x5.
Pulse shift:	0 - 9" (steel) can be changed to 0 - 19.5" (steel).

Pulse repetition frequency:	1 kHz/500 Hz/250 Hz/125 Hz, coupled to the test ranges, can be changed to half values.
Monitor gate:	single channel monitor with positive/negative logic and recorder output.
Independent monitor gate:	the width of the gate can be set from .04" (steel) to 100% with reference to be horizontal graduation of the CRT screen scale. The set gate range remains independent from the testing range!
Monitor threshold with reverse functions:	adjustable from 0-100% with reference to the vertical graduation of the CRT screen scale. Three-point switch for monitor function ON/OFF, coincidence (signal generation if the threshold is exceeded) and anti-coincidence (signal generation if the threshold is not reached).
Monitor signal generation:	positive/negative output coupled with an optical signal by means of a build-in luminous diode and an acoustical signal by means of a built-in buzzer which can be switched off.
Monitor switching output:	12 V d.c., load max. 500 mA.
Monitor recorder output:	connection for attachment recorder SRM 2 or the luminous location indicator LOS 1.

High functional stability:	vertical deflection drift < 0.1 dB per 10° C, test range drift < 1% per 10° C with reference to the extent of the range, adjusted pulse shift drift < 0.5% per 10° C, gate position drift < 0.5% per 10° C with reference to the length of the scale.
Voltage supply:	8 hours operating time with one battery charge (12-15 V; app. 450 mA; app. 5.5 W).
Batteries:	2 lead batteries or 2 NiCd batteries
Line operating and battery charge:	by means of pulg-in line/charger or separate charger 110-220V = 15%, suitable for charging both types of batteries.
Battery check:	by means of a luminous diode and an automatic switch-off facility.
Operating temperature:	-15 to + 40° C.
CRT screen scale:	2-3/4" x 2-1/8" with internal graticule.
Dimensions:	5-1/8" x 9-7/8" x 13" (11 x W x D).
Weight:	16.5 lbs. with batteries, without line/charger.

FRONT PANEL CONTROLS, INDICATORS AND CONNECTORS

BASIC INSTRUMENT CONTROLS

USL Model					ITEM	FUNCTION
31	32	36	37	38		
X	X	X	X	X	Cathode Ray Tube (CRT) Screen (1)	Video display of test information.
X	X	X	X	X	PWR/OFF SWITCH (2)	Switches power on or off to all instrument circuits.
X	X	X	X	X	TRANSMIT CONNECTOR (3)	Connects transmitting transducer to instrument transmitter output when TRANSDUCER MODE SWITCH is in DUAL/THRU Position. Connects single transducer to transmitter output and receiver input, for pulse-echo operation when Transducer Mode Switch is in SINGLE HI SENS or SINGLE DAMP position.
X	X	X	X	X	RECEIVE CONNECTOR (4)	Connects receiving transducer to instrument receiver input when Transducer Mode Switch is in DUAL/THRU Position. Connects single transducer to transmitter output and receiver input, for pulse echo operation when Transducer Mode Switch is in SINGLE HI SENS or SINGLE DAMP Position.

FRONT PANEL CONTROLS, INDICATORS AND CONNECTORS

BASIC INSTRUMENT CONTROLS

USL Model					ITEM	FUNCTION
31	32	36	37	38		
X	X	X	X	X	MHZ Switch (5)	Selects tuned frequencie of 2.5 MHz or 5 MHz. Selects broadband operation in BB position
X	X	X	X	X	DUAL/THRU-SINGLE HI SENS - SINGLE DAMP (Transducer Mode Switch) (6)	DUAL/THRU position sets up instrument for two transducer tests, such as thru-transmission, or dual probe pulse echo tests. SINGLE HI SENS position provides fixed damping for high sensitivity, single prob pulse-echo testing. SINGLE DAMP position provides variable damping via DAMP control for all single probe, pulse-echo tests.
X	X	X	X	X	BATT (Battery) (7)	LED indicator showing condition of rechargeable batteries. When LED is off, battery voltage is sufficient to operate the instrument. Flashing LED indicates that batteries are approachin exhaustion. Steady LED light indicates that batteries are exhausted.
X	X	X	X	X	DAMP (Damping) Control (8)	Adjusts length of initial pulse. Used to achieve proper balance of test sensitivity and resolution. DAMP control is active only when Transducer Mode Switch is set to SINGLE DAMP position.

BASIC INSTRUMENT CONTROLS

USL Model 31	32	36	37	38	ITEM	FUNCTION
X	X	X	X	X	REJ (Reject) Control (9)	Provides adjustment for suppression of undesired, low amplitude signals. The Reject Control on USL instruments is linear and will not disturb vertical linearity.
X	X	X	X	X	GAIN 0-20-40-60 (Coarse dB Gain) Control (10)	Provides calibrated gain adjustment in increments of 20 dB, from 0 to 60 dB
X	X	X	X	X	GAIN 0 - 40 (Fine dB Gain Control) (11)	Provides calibrated gain adjustment in increments of 2 dB, from 0 to 40 dB.
X	X		X		GAIN (Fine Uncalibrated) (12)	Provides analog adjustment of gain. Used to make exact adjustment of reference echo to horizontal reference line Note: On USL-36 and 38 instruments, this control position is utilized for a dual function gain control which performs as both the Fine Uncalibrated Gain and the DAC Curve Amplitude Control (24).
X	X	X	X	X	SWEEP COARSE (Coarse Sweep Range Control) (13)	Adjusts coarse range of horizontal sweep in increments of 0.5", 2.5" 10" and 50". Each of the four dial markings indicate the minimum range available for that dial setting. Dial markings are calibrated for longitudinal velocity in steel.

FRONT PANEL CONTROLS, INDICATORS AND CONNECTORS

BASIC INSTRUMENT CONTROLS

USL Model 31	32	36	37	38	ITEM	FUNCTION
X	X	X	X	X	FINE (Fine Sweep Range Control) (14)	Multiplies dial markings of Coarse Sweep Range settings to achieve calibration for a particular material, wav mode and range. Functions as a fine velocity control.
X	X	X	X	X	DELAY Control (15)	Provides vernier adjustment for activatin initial pulse relative to the start of the sweep.
X	X	X	X	X	FOCUS Control (16)	Adjusts sweep trace for sharpest image.

GATE (MONITOR) CONTROLS

USL Model 31	32	36	37	38	ITEM	FUNCTION
	X	X	X	X	POS-OFF-NEG Switch (17)	Gate is deactivated in OFF position. In POS position, gate is set for positive logic (alarm triggered when height of echo within time gate exceeds threshold level). In NEG position, gate is set for negative logic (alarm triggered when height of echo within time gate falls below threshold level).
	X	X	X	X	ALARM L.E.D. (18)	Flashes when gate alarm is triggered (see POS-OFF-NEG above).
	X	X	X	X	HORN On/Off Switch (19)	In ON position, an audibl signal is heard when gate alarm is triggered (see POS-OFF-NEG above). Audible signal is silence in OFF position.
	X	X	X	X	THRESHOLD Control (20)	Adjusts gate alarm triggering threshold to the desired level of CRT screen height.
	X	X	X	X	WIDTH Control (21)	Adjusts width or time duration of gate.
	X	X	X	X	DELAY Control (22)	Positions starting point of gate.

ELECTRONIC DAC (DISTANCE AMPLITUDE CORRECTION) Controls

USL Model 31	32	36	37	38	ITEM	FUNCTION
		X		X	OFF-ON DSP (DAC Mode Selector Switch) (23)	DAC is deactivated in OFF position, activated in DSP and ON positions. In DSP position, recommended for DAC setup, DAC slope is displayed on separate sweep line. In ON position, recommended for actual testing, DAC slope although operational, is not displayed.
		X		X	GAIN Control (24)	A dual function control. Adjusts DAC curve amplitude when DAC circuit is activated. Functions as uncalibrated fine gain control for instrument when DAC is deactivated.
		X		X	DLY (Delay) Control (25)	Positions starting point of DAC slope.
		X		X	SLP (Slope) Control (26)	Adjusts DAC curve slope rate.

DIGITAL READOUT CONTROLS

USL Model 31	32	36	37	38	ITEM	FUNCTION
			X	X	OFF-DUAL/SHEAR-CONT-MULT ECHO-INT/1ST (Digital Display Mode Switch) (27)	Selects the mode of operation for which the digital display is to be used. DUAL/SHEAR mode is selected when the test is to be performed with a dual element or shear wave (angle beam) transducer. CONT (Contact) mode is used with single element contact probes. This mode measures from an adjustable non-gated artifical start point to the first echo in the gate. MULT ECHO (Multiple Echo) mode is used with single element contact probes for measurement between the first two echoes in the gate. INT/1ST (Interface to First Echo) is used with single element delay line probes for measuring from the first interface echo to the first backwall echo. Both echoes must be in the gate.
			X	X	Digital Readout (28)	Provides a 3½ Digit display for Thickness and Distance.
			X	X	MTL CAL (Material Calibration) (29)	Used to calibrate Digital Readout for velocity of sound traveling in test material.

DIGITAL READOUT CONTROLS

USL Model 31	32	36	37	38	ITEM	FUNCTION
			X	X	ZERO ADJ (Zero Adjustment) (30)	Used to adjust zero start point (acoustic zero) of Digital Readout. Operational for all Digital Readout modes except MULT ECHO.
			X	X	RANGE 2" - 20" (31)	Coarse Range selection for Digital Readout: Max reading 1.999" and 19.99" respectively.
			X	X	Light Sensitive Diode (32)	Senses ambient light level. Causes Digital Readout to be backlighted when ambient light level is low, functions only while a measurement is being taken.
			X	X	SURF-SND PTH-DPTH Switch (33)	Selects sound path, surface (projection) distance or depth dimension to flaw for digital display during angle beam inspection.
			X	X	Surface Control (34)	Adjusts digital display of surface (projection) distance. Adjustment varies with test angle.
			X	X	Depth Control (35)	Adjusts digital display of depth dimension to flaw. Adjustment varies with test angle.

PRELIMINARY CONTROL SETTINGS

UEL Model 31	32	36	37	38	FUNCTION	SETTING
X	X	X	X	X	PWR/OFF Switch (2)	PWR
X	X	X	X	X	TRANSMIT Connector (3)	Connect coaxial cable to connector. Connect mid-frequency probe (2-6 MHz, 5 MHz preferred) to other end of cable.
X	X	X	X	X	RECEIVE Connector (4)	None required
X	X	X	X	X	MHZ SWITCH (5)	Set to frequency nearest frequency of probe.
X	X	X	X	X	DUAL/THRU-SINGLE HI SENS-SINGLE DAMP (Transducer Mode Switch) (6)	Set to SINGLE HI SENS
X	X	X	X	X	BATT (7)	Check that LED is not lit. If LED flashes or remains lit, batteries need recharging. If LED is not lit, and there is no sweep on CRT, batteries may be fully discharged, disconnected, or instrument has malfunctioned. Note: LED will flash momentarily when instrument is switched on.
X	X	X	X	X	DAMP (Damping) Control (8)	Fully counter-clockwise
X	X	X	X	X	REJ (Reject) Control (9)	Fully counter-clockwise
X	X	X	X	X	0-20-40-60 (Coarse dB Gain) Control (10)	Set to 0
X	X	X	X	X	GAIN (Fine dB Gain) Control (11)	Set to 0
X	X		X		GAIN (Fine Uncalibrated) (12)	Fully counter-clockwise
		X		X	GAIN Control (24)	Fully counter-clockwise

31	32	36	37	38		
X	X	X	X	X	SWEEP COARSE (Coarse Sweep Range) Control (13)	Set to 2.5" (50mm on metric instruments)
X	X	X	X	X	FINE (Fine Sweep Range) Control (14)	Fully Counter-clockwise
X	X	X	X	X	DELAY Control (15)	Turn clockwise or counter-clockwise, as required, until Initial Pulse appears at left side of CRT screen.
X	X	X	X	X	FOCUS Control (16)	Adjust for sharpest possible CRT trace.
	X	X	X	X	POS-OFF-NEG Switch (17)	OFF
	X	X	X	X	HORN On/Off Switch (19)	OFF
		X		X	OFF-ON DSP (23) (DAC Mode Selector Switch)	OFF
			X	X	OFF-DUAL/SHEAR-CONT- (27) MULT ECHO-INT/1ST (Digital Display Mode Switch)	OFF

FOR THE REMAINDER OF THE CONTROLS, NO ADJUSTMENT IS REQUIRED TO PERFORM THE FAMILIARIZATION PROCEDURE.

Familiarization Procedure

Basic Controls

1. Place a small amount of couplant on the surface of a 1" thick steel or aluminum block and couple the probe to the surface.

2. Adjust the Fine Calibrated GAIN control so that several echoes appear on the CRT screen. (The actual number of echoes displayed is unimportant at this point.) These echoes represent reflections from the back surface of the test material, as shown in figure 4.2a. Observe the effect of adjusting the Fine Calibrated GAIN control. Note that this is a stepped control. Each step changes the gain by 2 dB (decibels). Decibels are a unit of measure for gain.

3. Rotate the Coarse Calibrated GAIN control thru the 0-20-40-60 dB positions and then return the control to zero. Note that this causes large changes in echo amplitude.

4. Turn the Uncalibrated GAIN Control clockwise and then counter-clockwise. Note that this makes very small gain changes possible.

5. Note that it is possible to achieve the same echo amplitude with different combinations of GAIN settings on the three controls.

6. Turn the Reject control clockwise and then fully counter-clockwise. Note that the lower amplitude echoes successively disappear from view as Reject is increased. Note, also, that the amplitude of higher amplitude echoes is unaffected while the lower amplitude echoes are being rejected. This demonstrates that the Reject control on USL Series instruments is <u>linear</u>, that is, adjustment of the Reject control does not disturb the proportionality of the higher amplitude, non-rejected echoes.

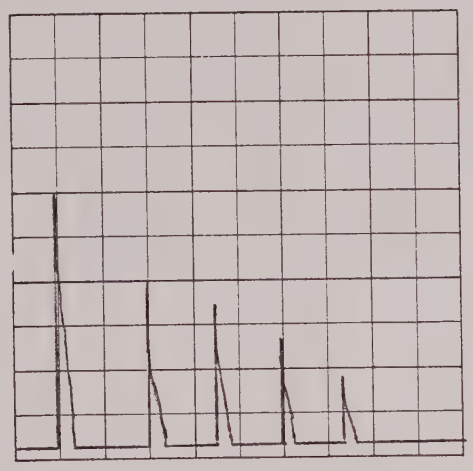


Figure 4.2a
Multiple Back Echoes

7. Rotate the Damping control clockwise and then back to the fully counter-clockwise position and note that there is no effect. This is because the Damping control is non-functional when the Transducer Mode Switch is in the SINGLE HI SENS position. Now set the Transducer Mode Switch to SINGLE DAMP and rotate the Damping control clockwise and counter-clockwise. Note that the width of the initial pulse changes as you do this. This is because the Damping control changes the duration of the initial pulse that is sent into the test material.

8. Turn the Transducer Mode Switch to DUAL/THRU. Note that the echoes are no longer displayed on the CRT. This is because the TRANSMIT connector is now connected only to the transmitter circuit and the RECEIVE connector is now connected only to the receiver. If you were to connect another probe and cable to the RECEIVE connector and place that probe on the opposite side of the test material as shown in figure 4.2b or employ dual element probe as shown in figure 4.2c, received signals would again be displayed on the CRT screen.

9. Rotate the DELAY control clockwise and counter-clockwise and note that the presentation of initial pulse and echoes is shifted to the left and right on the CRT screen. Observe that adjustment of the DELAY has no effect on the spacing between signals displayed on the CRT screen.

10. Turn the Fine Sweep Control clockwise and counter-clockwise. Note that this changes the spacing between signals displayed on the CRT screen.

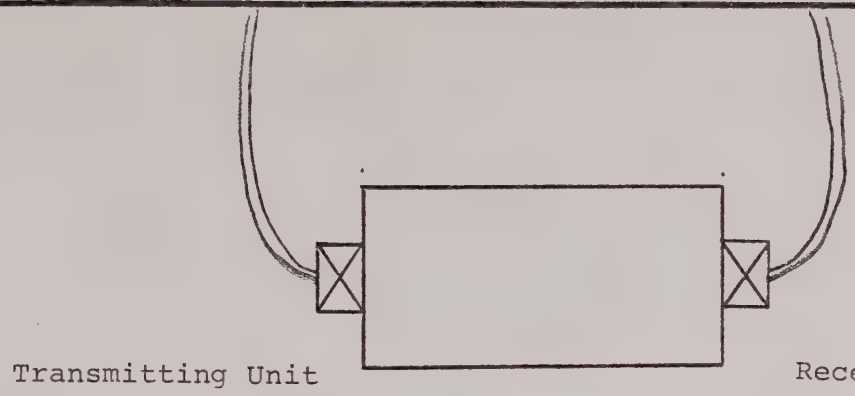


Figure 4.2b
Through Transmission Technique

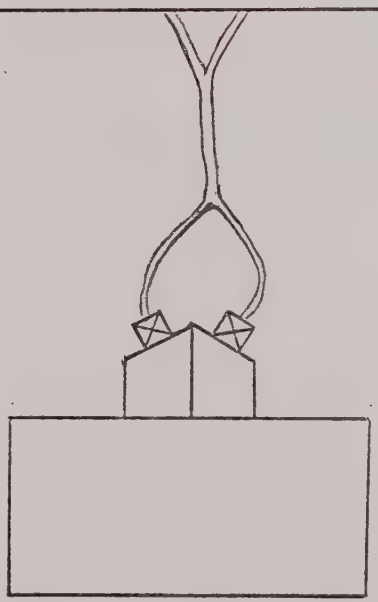


Figure 4.2c
Dual Element Probe

11. Rotate the Coarse Sweep Control thru the .5, 2.5, 10 and 50 inch positions. Note that this causes large changes in the spacing between signals displayed on the CRT screen.

12. Turn the FOCUS control clockwise and counter-clockwise and observe that this blurs the trace. Readjust the FOCUS for the sharpest possible trace.

13. Practice the above-described control manipulations until you are thoroughly familiar with the effect of each control and can remember the effect of each control. Complete familiarity with the controls will greatly simplify your work with the instrument. The controls that you have just operated are the basic instrument controls and are common to all USL Series instruments covered in this manual. The remaining controls pertain to accessory features and will be covered in the individual sections of this manual which discuss those features.

GATE (MONITOR)

The USL-32, USL-36, USL-37 and USL-38 instruments are equipped with a gate (monitor) circuit. The gate provides a visual and audible signal that a certain condition exists regarding the test material. In addition, test information detected by the gate may be fed to auxiliary equipment via gate output connectors. Auxiliary equipment may consist of external alarm devices, data recorders, etc. Typical uses of gate circuits are:

1. To signal that reflectors of larger than a predetermined amplitude have been detected in the test specimen. The gate may be adjusted to warn that such reflectors exist throughout the depth of the test material or within only a certain cross-section of the depth, for example, the third through seventh inch cross-section of a ten inch thick specimen. This is called "positive logic" gating.

2. To signal a loss of back reflection, caused by the presence of a large reflector or highly attenuative condition within the test material. This is called "negative logic" gating.

3. To signal that test material thickness is less than a predetermined minimum.

4. To signal that test material thickness is greater than a predetermined maximum.

GATE ADJUSTMENT

Two conditions must be met in order for the gate to provide an alarm signal:

a. An echo must occur within the gate step on the base line sweep.

b. The echo must have an amplitude appropriate for triggering the gate alarm threshold.

The starting point and width of the gate step are adjustable by means of the GATE DELAY and WIDTH controls. The THRESHOLD control adjusts the amplitude of the gate alarm threshold. The position of the POS-OFF-NEG switch determines whether the gate alarm will be triggered by an echo peak which is higher or lower in amplitude than the gate alarm threshold.

Procedure

1. Determine whether the gate alarm is to be triggered by echo peaks which fall above or below the gate alarm threshold. Set the POS-OFF-NEG switch to POS if the gate alarm is to be triggered by echo peaks which fall above the gate alarm threshold. Set the POS-OFF-NEG switch to NEG if the gate alarm is to be triggered by signals which fall below the gate alarm threshold.

2. Adjust the leading edge of the gate step along the base line sweep with the GATE DELAY control.

3. Adjust the trailing edge of the gate step along the base line sweep with the GATE WIDTH control.

4. If audible gate alarming is desired, set the HORN switch to the ON position.

5. Using a back reflection or other reference reflector, place an echo within the gate step. By means of the GAIN controls and appropriate pressure on the probe, adjust the peak of the echo to appear at the amplitude desired for triggering the gate alarm. Adjust the THRESHOLD control to a position which just begins to trigger the gate alarm.

Note: The GATE must be operating when the digital readout feature in USL-37 and USL-38 instruments is utilized. When the gate is employed for this purpose, turn the THRESHOLD control fully counter-clockwise to the THICKNESS detent.

ELECTRONIC DAC (DISTANCE AMPLITUDE CORRECTION) CIRCUIT

The echo amplitude of a reflector varies with distance as well as reflector size. It is necessary to correct for distance effects before reflectors located at various distances in the test material can be properly evaluated for size.

Amplitude variations caused by variations in distance result from the fact that a sound beam consists of two zones, a near field and a far field. Echo amplitude increases as reflectors are positioned further from the test surface, reaching a peak amplitude at the end of the near field. In the far field, echo amplitude steadily decreases according to the inverse square law as reflectors are positioned further out along the axis of the sound beam. That is, in the far field, the amplitude of a given size reflector is inversely proportional to the square of the reflector's distance along the beam axis. In addition, the material attenuation properties of different test materials will exert yet another effect on the variations of echo amplitude with distance.

There are various methods of correcting echo amplitude for the effects of distance, each method having its own applications and advantages. In that electronic DAC has the advantage of displaying echoes already corrected for distance on the CRT screen, this method is ideal for use when a gating circuit is employed to warn that reflectors of a certain size or larger have been sensed.

In that near field length and far field beamspread vary with transducer size and frequency, as well as material velocity, electronic DAC must be adjusted differently when these factors vary. Likewise the material attenuation properties of different test materials exert their own individual effects on distance losses and should be considered as a variable even when transducer size and frequency, as well as material velocity, remain constant.

To adjust the Electronic DAC Circuit, proceed as follows:

1. Obtain a test block made of the same material as the object to be tested. This test block should have a series of reflectors, such as side-drilled or flat bottomed holes, located in the test block so as to span the range of distance that will be encountered in the proposed test. Ideally, these reflectors should be of a size that produces a reflection the same amplitude as the critical reflector size of the proposed test. Critical reflector size is the size of the largest reflector considered to be acceptable for the test material.

2. Calibrate the instrument, exclusive of electronic DAC controls, for a distance range suitable for the material to be tested.

3. Apply the transducer to the test block and note the amplitudes of the reflectors at various distances. Identify the reflector with the highest amplitude. It is advisable to mark its position along the base line sweep with a china marking pen or grease pencil.

4. Turn the DAC Mode Selector Switch to DSP. Note that an additional trace line appeared above the base line sweep. This additional trace indicates the shape of the Distance Amplitude Correction curve that the instrument will apply to echoes returned from the test material.

5. Manipulate the DAC GAIN, DLY and SLP controls to become familiar with the effect of these controls on the DAC curve. Note that the "curve" consists essentially of a line that progresses horizontally, then climbs, and then progresses horizontally again.

6. Using the DAC DLY control, position the point where the curve begins to climb so that it appears just to the right of the point where the reflector with the highest amplitude appeared in step 3 above. The DAC GAIN control will now govern the amplitude of reflectors appearing to the left of this point, whereas the DAC SLP control will adjust the slope of correction applied to reflectors appearing to the right of this point.

7. Moving the transducer from one reflector to the next, adjust the DAC GAIN and DAC SLP controls so that all reflectors appear at an amplitude of 50% of CRT screen height. When this has been accomplished, the electronic DAC is properly adjusted for the test.

8. Turn the DAC mode selector switch to ON. This will eliminate visible display of the DAC curve.

NOTE: If the same test is to be repeated in the future, make a drawing or photograph of the displayed DAC slope, so that the same distance correction may be easily repeated.

DIGITAL READOUT

USL-36 and USL-38 instruments are equipped with a digital readout. This feature simplifies testing in that it eliminates the need to study the CRT base line sweep when making thickness and distance measurements. It also provides a higher degree of measuring accuracy than is available from use of the CRT screen alone. Whereas the CRT base line provides a maximum reading accuracy to $\pm$ .005", maximum reading accuracy of the digital readout is .001". In addition to the four thickness and distance measurement modes described in this section, the digital readout also provides surface (projection) distance and flaw depth information for angle beam inspection.

DUAL/SHEAR

The DUAL/SHEAR mode is used for distance and thickness measurement with dual element probes and distance measurement with angle beam shear wave probes.

Dual element probes are ideal for wall thickness measurement down to a lower limit of .030" - .050", depending upon the probe design. The most common applications are measurement of remaining wall thickness on corroded, erroded and pitted samples.

Angle beam shear wave probes are used for detection and evaluation of flaws oriented obliquely to the test surface. Inspection of weldments is the most common application.

Dual element probe calibration procedure:

1. Attach probe cable connectors to the TRANSMIT and RECEIVE connectors on the instrument.
2. Set the Probe Mode Switch to DUAL/THRU.
3. Using the SWEEP and DELAY controls calibrate the CRT sweep as described in section 9.2.2..
4. Set the POS-OFF-NEG switch to POS.
5. Turn the GATE THRES control fully counter-clockwise (thickness position).
6. Using the GATE DELAY control, position the leading edge of the gate step on the CRT screen so that the thinnest measurement to be taken will fall within the gate.
7. Using the GATE WIDTH control, position the trailing edge of the gate step on the CRT screen so that the thickest measurement to be taken will fall within the gate.

Dual/Shear (Continued)

8. Set the Digital Readout Mode Switch to DUAL/SHEAR.

9. Set the Digital Readout Range Switch to 2" or 20", depending upon the desired thickness range.

10. Turn the ZERO Control clockwise and counter-clockwise to identify the Zero Start Signal. The Zero Start Signal will appear as a "step" on the CRT sweep line and will move left or right on the CRT sweep line as the ZERO Control is turned. (The width of the "step" of the Zero Start Signal will vary with the setting of the MTL CAL control. However, the width of the step can be ignored as we are concerned with only the leading edge of the Zero Start Signal).

11. Using the ZERO Control set the leading edge of the Zero Start Signal at the "0" graticule on the horizontal sweep scale.

12. Using two reference blocks whose thicknesses bracket the thickness range of the samples to be tested, couple the probe to the thicker block. Adjust the MTL CAL control so that the Digital Readout displays the thickness of the thicker block.

13. Now couple the probe to the thinner block and adjust the ZERO Control so that the Digital Readout displays the thickness of the thinner block.

14. Repeat steps 12 and 13 until the Digital Readout displays the correct thickness for both blocks. When that has been achieved, the Digital Readout is properly calibrated to display thickness.

NOTE: This procedure can be shortened by adjusting the MTL CAL and ZERO Controls separately as follows:

Dual/Shear (Continued)

a) Couple the probe to the thicker of the two blocks and adjust the MTL CAL Control until the Digital Readout displays approximately the correct value.

b) Couple the probe to the thinner of the two blocks. Now adjust the MTL CAL control until the readout displays a value which is equal to the value displayed in step (a), minus the difference in thickness between the two blocks.

c) Repeat steps (a) and (b) until the difference between the two values is exactly equal to the difference in thickness between the two blocks.

d) Couple the probe to the thinner of the two blocks and adjust the ZERO ADJ control until the Digital Readout displays the correct value for the thickness of that block.

e) Couple the probe to the thicker of the two blocks and confirm that the Digital Readout is displaying the appropriate value for the thickness of that sample. If the correct value is not being displayed, return to step (a).

Angle Beam shear wave probe calibration procedure:

1. Set up the CRT display for angle beam testing as described in Section 11.

2. Set the POS-OFF-NEG switch to POS.

3. Turn the GATE THRES control fully counter-clockwise (thickness position).

4. Using the GATE DELAY control, position the leading edge of the gate step on the CRT screen so that the thinnest measurement to be taken will fall within the gate.

Dual/Shear
Angle Beam shear wave probe calibration procedure: (continued)

5. Using the GATE WIDTH control, position the trailing edge of the gate step on the CRT screen so that the thickest measurement to be taken will fall within the gate.

6. Set the Digital Readout Mode Switch to DUAL/SHEAR.

7. Set the Digital Readout RANGE switch to 2" or 20" depending upon the desired test range. (For the purposes of this explanation, calibration procedure will be illustrated using the IIW Block with reference echoes at 4" and 9". Since these reference echoes will be used to calibrate the Digital Readout to a 10" range, the Digital Readout RANGE switch will be set to the 20" position.)

8. With the probe coupled to the IIW Block to show the 4" and 9" echoes properly at the 4 and 9 graticule marks on the horizontal sweep, adjust the GATE DELAY control so that only the 9" reference echo appears in the gate. Now using the MTL CAL control, adjust the Digital Readout to display 9.

9. Adjust the GATE DELAY control so that the 4" reference echo again appears in the gate. Now using the ZERO control adjust the Digital Readout to display 4.

10. Repeat steps (8) and (9) until the Digital Readout displays the correct value for both the 4" and 9" reference echoes. When that has been achieved, the Digital Readout is properly calibrated to display angular sound path distance.

NOTE: Calibration of the Digital Readout for Angle Beam Shear Wave probes may be shortened using the same technique employed for Dual Probes, above. That is, using the 4" and 9" reference reflectors and adjusting the GATE DELAY so that first one and then the other reflector appears as the first signal in the gate, adjust the MTL CAL control so that the two reflectors are digitally displayed as being 5" apart (the difference between 4" and 9"). Then, using the ZERO ADJ Control adjust the Digital Readout to display 4 for the 4" reflector. Then verify that the 9" reflector reads 9. Readjust the MTL CAL and ZERO ADJ, if necessary, to achieve the proper displayed values.

Once the Digital Readout has been calibrated to display angular sound path, it is also possible to set up the Digital Readout to display Surface (Projection) Distance and Depth to the flaw. Refer to Section 8 for procedure.

CONTACT

The CONTACT mode is used for single element, non-delay type, contact probes. Typical applications include flaw depth and wall thickness of thicker specimens.

CONTACT Calibration Procedure

1. Calibrate the instrument horizontal sweep for single element probe contact testing as described in Section 9.2.1..

2. Set the POS-OFF-NEG switch to POS.

3. Turn the GATE THRES control fully counter-clockwise (thickness position).

4. Using the GATE DELAY control, position the leading edge of the gate step on the CRT screen so that the thinnest measurement to be taken will fall within the gate.

5. Using the GATE WIDTH control, position the trailing edge of the gate step on the CRT screen so that the thickest measurement to be taken will fall within the gate.

6. Set the Digital Display Mode Switch to MULT.

7. Couple the probe to the reference block and display at least two back reflections in the gated portion of the horizontal sweep.

8. Adjust MTL CAL control so that the Digital Readout displays the thickness of the reference block.

9. Set the Digital Display Mode Switch to CONTACT. Now using the ZERO ADJ control adjust the Digital Readout to display the thickness of the reference block.

MULT ECHO

The Multiple Echo Mode is used with single element, non-delay contact probes to take thickness readings between two gated back reflections. This method provides higher resolution with contact probes than is obtainable using the CONTACT Mode, above.

MULT ECHO Calibration Procedure

1. Using the DELAY control, set the initial pulse near the "0" graticule on the horizontal sweep.
2. Set the POS-OFF-NEG switch to POS.
3. Turn the GATE THRES control fully counter-clockwise (thickness position).
4. Using the GATE DELAY and GATE WIDTH controls, adjust the gate step so that it will be capable of containing 2 successive back reflections from both the thinnest and thickest specimens you intend to measure.
5. Set the Digital Display Mode Switch to MULT ECHO.
6. Set the Digital Readout RANGE Switch to 2" or 20" depending upon the desired thickness range.
7. Couple the probe to the reference block.
8. While observing two or more back reflections appearing in the gated portion of the sweep, adjust the MTL CAL control so that the Digital Readout displays the thickness of the reference block.

Note: The ZERO ADJ Control is not used during MULT ECHO calibration.

INT/1ST

The Interface to First Echo Mode is used with single element delay line probes to take thickness readings from the delay line/test surface interface to the first back reflection. This method provides excellent resolution and is ideal for measuring the thickness of thin materials having smooth, parallel surfaces.

Interface to First Echo Calibration Procedure

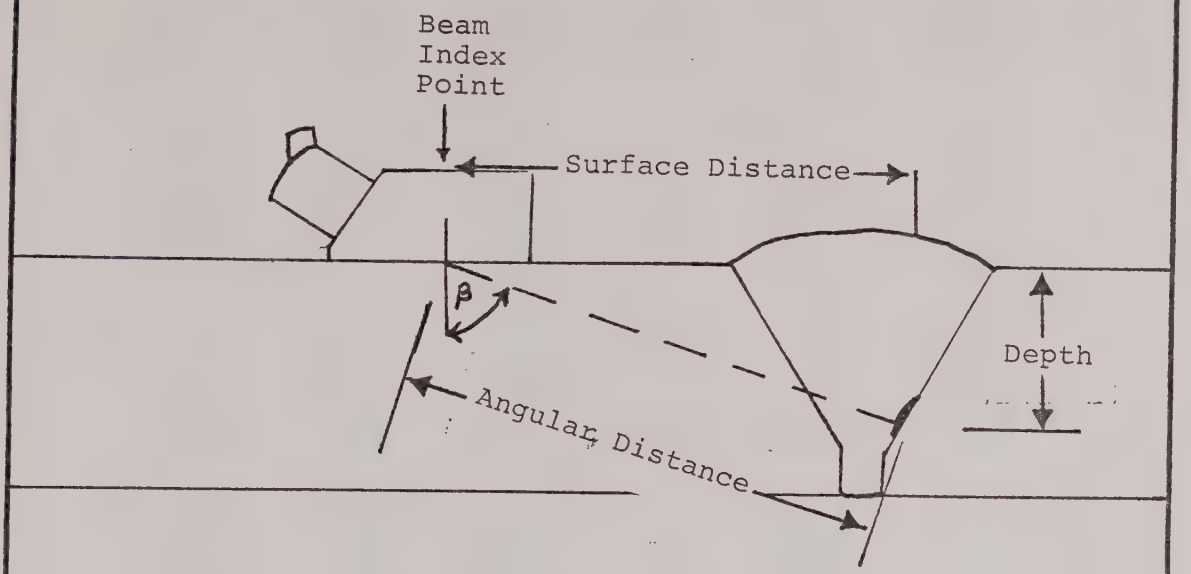
1. Using the DELAY Control, set the initial pulse near the "0" graticule on the horizontal sweep.
2. Set the POS-OFF-NEG switch to POS.
3. Turn the GATE THRES control fully counter-clockwise (thickness position).
4. Using the GATE DELAY and GATE WIDTH controls, adjust the gate step so that it will be capable of containing 2 successive back reflections from both the thinnest and thickest specimens you intend to measure.
5. Set the Digital Readout Mode Switch to MULT ECHO.
6. Set the Digital Readout RANGE Switch to 2".
7. Couple the probe to the reference block.
8. While observing two or more back reflections appearing in the gated portion of the sweep, adjust the MTL CAL control so that the Digital Readout displays the thickness of the reference block. At this point, only back reflections, not the interface signal, are in the gate.
9. Set the Digital Readout Mode Switch to INT/1ST using the ZERO Control. Adjust the Digital Readout to display the thickness of the reference block. At this point, the interface signal, as well as at least the first back reflection, are in the gate.

Automatic Digital Display of Surface (Projection) Distance and Depth for Angle Beam Inspection

When performing angle beam inspection of weldments, it is usually necessary to determine surface (projection) distance from the probe beam index point to the point on the surface directly above the flaw, as well as the depth of the flaw. This is done by employing the trigonometric principles shown in Figures 8a, 8b. The USL-37 and USL-38 instruments, however, will perform this task automatically, displaying the desired information on the Digital Display.

Procedure

1. Calibrate the USL-37 or USL-38 as you normally would for Angle Beam Inspection.
2. Set the Digital Display Mode Selector Switch to the DUAL/SHEAR position.
3. Couple the probe to a reference block which has a reflector at known distance of sound path length, surface (projection) distance and depth. The "4" radius of an IIW Block is ideal for this purpose.
4. Set the SURF-PATH-DPTH Switch to the PATH position.
5. Adjust the Mat'l Cal and Dly controls to display the actual sound path distance on the Digital Display as explained in Section 7.
6. Set the SURF-PATH-DPTH switch to SURF and adjust the SURFACE control until the Digital Display shows the actual surface distance.
7. Set the SURF-PATH-DPTH switch to DPTH and adjust the DEPTH control until the Digital Display shows the actual depth of the reflector from the surface of the reference block.



Surface Distance = Sin β X Angular Distance

Depth = Cos β X Angular Distance

Figure 8a

Angle	Sin	Cos	Tan	Angle	Sin	Cos	Tan
1 °	.0175	.9998	.0175	46°	.7193	.6947	1.0355
2 °	.0349	.9994	.0349	47°	.7314	.6820	1.0724
3 °	.0523	.9986	.0524	48°	.7431	.6691	1.1106
4 °	.0698	.9976	.0699	49°	.7547	.6561	1.1504
5 °	.0872	.9962	.0875	50°	.7660	.6428	1.1918
6 °	.1045	.9945	.1051	51°	.7771	.6293	1.2349
7 °	.1219	.9925	.1228	52°	.7880	.6157	1.2799
8 °	.1392	.9903	.1405	53°	.7986	.6018	1.3270
9 °	.1564	.9877	.1584	54°	.8090	.5878	1.3764
10°	.1736	.9848	.1763	55°	.8192	.5736	1.4281
11°	.1908	.9816	.1944	56°	.8290	.5592	1.4826
12°	.2079	.9781	.2126	57°	.8387	.5446	1.5399
13°	.2250	.9744	.2309	58°	.8480	.5299	1.6003
14°	.2419	.9703	.2493	59°	.8572	.5150	1.6643
15°	.2588	.9659	.2679	60°	.8660	.5000	1.7321
16°	.2756	.9613	.2867	61°	.8746	.4848	1.8040
17°	.2924	.9563	.3057	62°	.8829	.4695	1.8807
18°	.3090	.9511	.3249	63°	.8910	.4540	1.9626
19°	.3256	.9455	.3443	64°	.8988	.4384	2.0503
20°	.3420	.9397	.3640	65°	.9063	.4226	2.1445
21°	.3584	.9336	.3839	66°	.9135	.4067	2.2460
22°	.3746	.9272	.4040	67°	.9205	.3907	2.3559
23°	.3907	.9205	.4245	68°	.9272	.3746	2.4751
24°	.4067	.9135	.4452	69°	.9336	.3584	2.6051
25°	.4226	.9063	.4663	70°	.9397	.3420	2.7475
26°	.4384	.8988	.4877	71°	.9455	.3256	2.9042
27°	.4540	.8910	5095	72°	.9511	.3090	3.0777
28°	.4695	.8829	.5317	73°	.9563	.2924	3.2709
29°	.4848	.8746	.5543	74°	.9613	.2757	3.4874
30°	5000	.8660	.5774	75°	.9659	.2588	3.7321
31°	.5150	.8572	.6009	76°	9703	.2419	4.0108
32°	.5299	.8480	6249	77°	.9744	.2250	4.3315
33°	.5446	.8387	.6494	78°	.9781	.2079	4.7046
34°	.5592	.8290	.6745	79°	.9816	.1908	5.1446
35°	.5736	.8192	.7002	80°	9848	.1736	5.6713
36°	.5878	.9090	,7265	81°	.9877	.1564	6.3138
37°	.6018	.7986	.7536	82°	.9903	.1392	7.1154
38°	.6157	.7880	.7813	83°	.9925	1219	8.1443
39°	.6293	.7771	.8098	84°	.9945	.1045	9.5144
40°	.6428	.7660	.8391	85°	9962	.0872	11.4301
41°	.6561	.7547	.8693	86°	.9976	.0698	14.3007
42°	.6691	.7431	.9004	87°	.9986	.0523	19.0811
43°	.6820	.7314	.9325	88°	.9994	.0349	28,6363
44°	.6947	.7193	.9657	89°	.9998	.0175	57,2900
45°	.7071	.7071	1.0000	90°	1.0000	.0000	

Figure 8b

During actual testing, when a reflector is detected, the Digital Readout will show sound path length when the SURF-PATH-DPTH Switch is set to PATH, Surface (projection) distance when this switch is set to SURF and depth of reflector from the surface of the test material when this switch is set to DPTH.

NOTE: When the digitally displayed depth exceeds the thickness of the test material, this is an indication that the sound beam has reflected from the opposite surface. In this case the digital readout is showing distance from the test surface to the opposite surface plus the distance from the opposite surface back up to the reflector. To determine the true position of the reflector, subtract the material thickness from the Digitally Displayed depth. This will give the distance of the reflector from the opposite surface. Subtract this latter figure from the material thickness to obtain the depth of the reflector from the test surface.

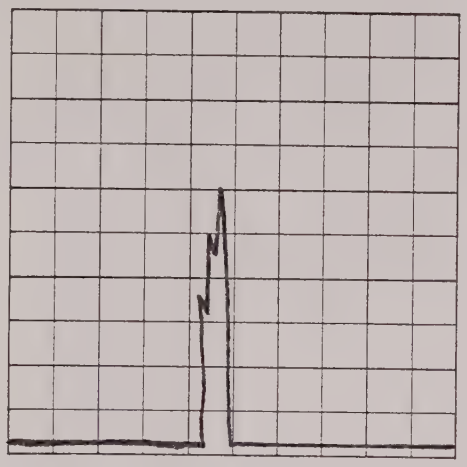
THICKNESS AND DISTANCE - GENERAL INFORMATION

This section contains calibration procedures for three thickness measurement techniques:

> Single Element Probe, Dual Element Probe and Delay Line Probe. For Single Element and Delay Line Probe techniques the Transducer Mode Switch must be set to either the SINGLE FIX DAMP or SINGLE DAMP position. For the Dual Element Probe technique, the Transducer Mode Switch must be set to the DUAL/THRU position.

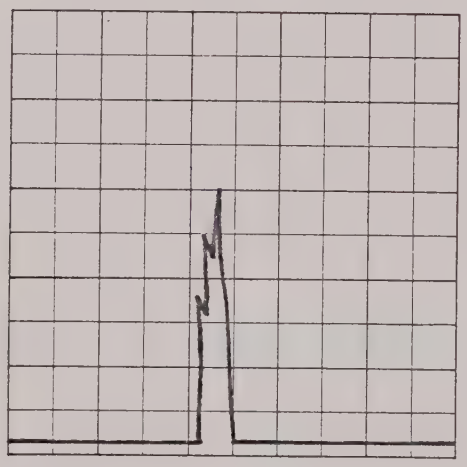
Thickness calibration is accomplished by proper positioning of the point where the leading edge of the calibration echoes break off from the base line sweep. Likewise, thickness measurements are taken by noting the position on the horizontal graticule scale where the leading edge of the back reflection breaks off from the base line sweep.

Echo amplitude, adjusted by the GAIN controls and by pressure on the probe, determines how many "pulse cycles" appear on a back reflection. When two back reflections are used for calibration, care should be taken that the same number of pulse cycles appear on both back reflections. When taking an actual thickness measurement, care should be taken that the echo from the test material has the same number of pulse cycles as the echo used for calibration. (See Figures 9.1a, 9.1b).



Calibration Echo

Figure 9.1a



Test Echo

Figure 9.1b

SINGLE ELEMENT PROBE CALIBRATION PROCEDURE

1. Couple the probe to the reference block and using the DELAY Control set the first back reflection to "0" on the horizontal sweep scale.

2. Using the FINE SWEEP control, adjust the second back reflection to read the thickness of the reference block.

3. Repeat steps (1) and (2) until, without further adjustment of the controls, the first back reflection appears at "0" and the second back reflection appears at the thickness of the reference block on the horizontal sweep scale.

4. Using the DELAY Control, adjust the first back reflection to appear at the thickness of the reference block on the horizontal sweep scale. This adjustment will also cause the initial pulse to move to the vicinity of "0" on the horizontal sweep scale.

DUAL ELEMENT PROBE CALIBRATION PROCEDURE

1. Set the Probe Mode Selector Switch to the DUAL/THRU position.

2. Connect the cable connectors from the Dual Element Probe to the TRANSMIT and RECEIVE connectors on the instrument.

3. Using the DELAY Control, move the initial pulse slightly off the left side of the CRT horizontal sweep scale.

4. Obtain two reference blocks whose thicknesses bracket the thickness range of the materials to be measured.

DUAL ELEMENT PROBE CALIBRATION PROCEDURE (Continued)

5. Couple the probe to the thicker of the two blocks and adjust the FINE SWEEP Control so that the back reflection appears at the thickness of that block on the horizontal sweep scale.

6. Couple the probe to the thinner of the two blocks and adjust the DELAY Control so that the back reflection appears at the thickness of that block on the horizontal sweep scale.

7. Repeat steps (5) and (6) until the respective echoes from each reference block appear at their correct position on the horizontal sweep scale.

NOTE: This procedure can be shortened by adjusting the FINE SWEEP and DELAY Controls separately as follows:

a) Couple the probe to the thicker of the two blocks and adjust the FINE SWEEP Control until the back reflection appears at the correct position on the horizontal sweep scale.

b) Couple the probe to the thinner of the two blocks. Now adjust the FINE SWEEP Control until the back reflection appears at a position which is equal to the value displayed in step (a), minus the difference in thickness between the two blocks.

c) Repeat steps (a) and (b) until the <u>difference</u> between the two displayed values is exactly equal to the difference in thickness between the two blocks.

DUAL ELEMENT PROBE CALIBRATION PROCEDURE (Continued)

d) Couple the probe to the thinner of the two blocks and adjust the DELAY control until the back reflection appears at its proper position on the horizontal sweep scale.

e) Couple the probe to the thicker of the two blocks and confirm that its back reflection appears at the proper position on the horizontal sweep scale. If the correct value is not being displayed, return to step (a).

DELAY LINE PROBE CALIBRATION PROCEDURE

1. Couple the probe to the reference block and, using the DELAY Control, set the Delay Line/Test Surface Interface echo at "0" on the horizontal sweep scale. This will cause the initial pulse to move off the left side of the CRT screen.

2. Using the FINE SWEEP Control, adjust the first back reflection to appear at the thickness of the reference block on the horizontal sweep scale.

3. Repeat steps (1) and (2) until, without further adjustment of the controls, the Interface signal appears at "0" and the first back reflection appears at the thickness of the reference block on the horizontal sweep scale.

Chapter 10

FLAW SIZE EVALUATION

Several methods are currently in use for the evaluation of flaw size, each having their individual merits. All methods are based on the use of the instrument for comparing flaws in the test material to a known size reflector in a reference standard. These reference reflectors may be flat-bottomed holes, side-drilled holes, notches, sawcuts or backwall echoes. The methods vary in technique as well as the amount of information that they provide.

To evaluate flaw size, two steps must be taken. First, the flaw being investigated must be compared to the reference reflector. Second, the flaw amplitude must be corrected for distance effects. Some methods of flaw size evaluation combine the two steps into a single operation.

In order to compare a flaw in the test material to a reference reflector, the operator must compare their echo amplitudes. This is done either by visually comparing echo height on the CRT screen or by making an electronic comparison by means of the instrument's calibrated gain controls.

Correction for distance effects may be accomplished by a number of different methods. They include:

1. Drawing Distance Amplitude Correction curves on the CRT screen.

2. Electronic Distance Amplitude Correction (described elsewhere in this manual).

3. The use of charts, called DGS diagrams, which contain a set of universally applicable Distance Amplitude Correction curves. (Available from Krautkramer-Branson).

4. Transparent overlays, containing Distance Amplitude Correction curves, which fit in front of the CRT screen (available from Krautkramer-Branson).

5. Sets of reference blocks containing flat-bottomed holes at various distances.

In addition to the above, distance/amplitude correction techniques have been devised for specific test applications. A representative selection of flaw size evaluation techniques may be found in A.S.M.E., A.S.T.M. and A.W.S. publications.

Four preliminary steps are required to set up the instrument for angle beam inspection:

1. Location of the transducer beam index (sound exit) point.
2. Checking of the refracted beam angle in the test material.
3. Calibration of the instrument sweep for distance.
4. Calibration of the instrument gain for reference sensitivity.

The first three steps are normally performed with an IIW Block. Numerous methods, however, are currently in use for sensitivity calibration. The techniques described here are primarily intended to illustrate the potentials of the instrument as an angle beam inspection tool. More specific information may be obtained by consulting A.W.S., A.S.M.E. and A.S.T.M. publications.

Location of the transducer beam index point

Couple the transducer to the IIW Block as shown in figure 11a. The first high amplitude echo appearing on the CRT screen after the initial pulse is a reflection from the large arc on the IIW Block. Move the probe forward and backward until the echo is brought to its maximum possible amplitude. Hold the probe in place and place a mark on the side of the probe directly in line with the scribe line on the IIW Block.

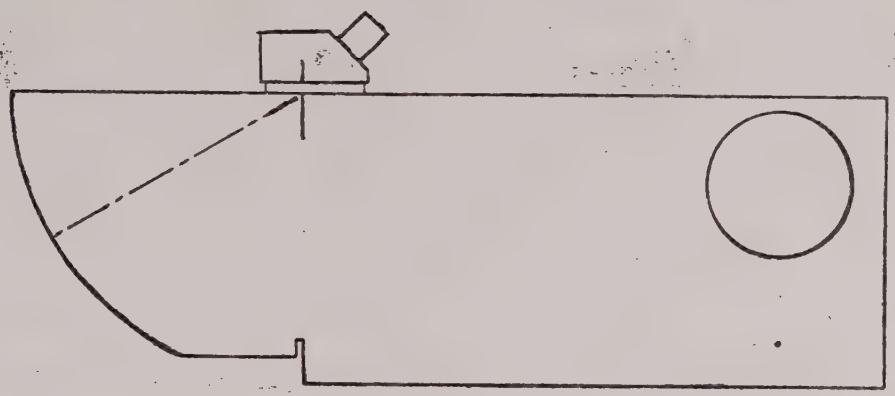


Figure 11a
Beam Index Point

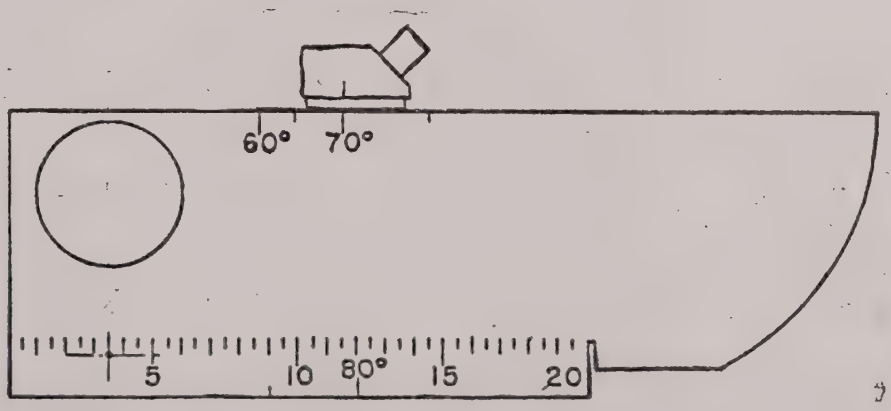


Figure 11b
70° Angle Check Position

Checking the Refracted Beam Angle

There are different positions on the IIW Block for checking the different beam angles. The position for checking a 70° angle beam transducer is shown in figure 11b. As with beam index location above, move the probe forward and backward, keeping the side of the probe parallel with the side of the block, until a maximum amplitude echo from the circle is obtained. Now hold the probe in place and note the point on the scale that the transducer beam index mark has become aligned with. This is the refracted angle of the probe in the test material.

Distance Calibration

Couple the transducer to the IIW Block as shown in figure 11c and adjust the fine range and delay controls so as to place the echoes at 4 and 9 on the CRT Screen for the Type 1 block or at 4 and 8 on the CRT Screen for the Type 2 block. The instrument sweep is now calibrated to a 10" range for angle beam shear waves.

Sensitivity Calibration

Obtain or fabricate a test block which contains a reference reflector whose reflecting amplitude is equivalent to that which would be obtained from the maximum size discontinuity that is considered acceptable for the material to be tested. In the example in figure 11d, side drilled holes have been chosen as reference reflectors.

Identify the reflector which produces the highest amplitude echo and adjust its peak with the gain controls to 75 - 80% CRT screen height. Then mark its peak with a grease pencil or china marking pen. Without changing the gain, obtain maximum amplitude echoes from the other reflectors and mark their peaks on the CRT screen also. Connect the marks with a smooth line as shown in figure 11e. You have now constructed a Distance Amplitude Correction Curve, a curve which shows the true amplitude of the reference reflector at various distances.

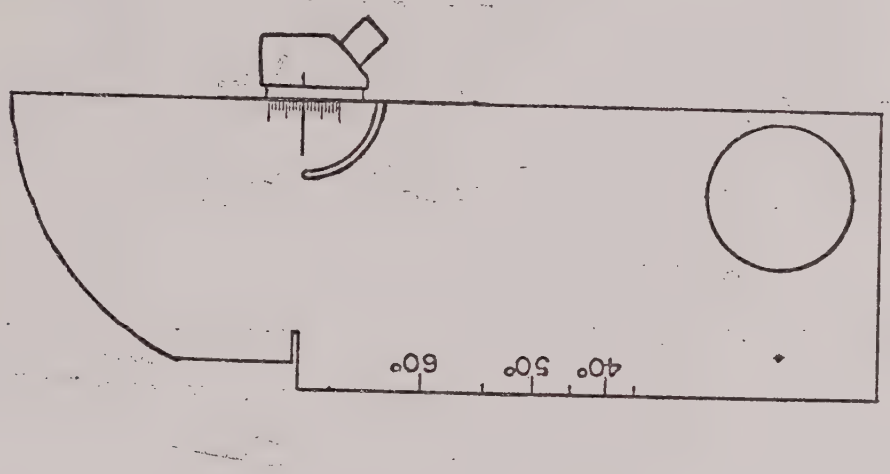


Figure 11c

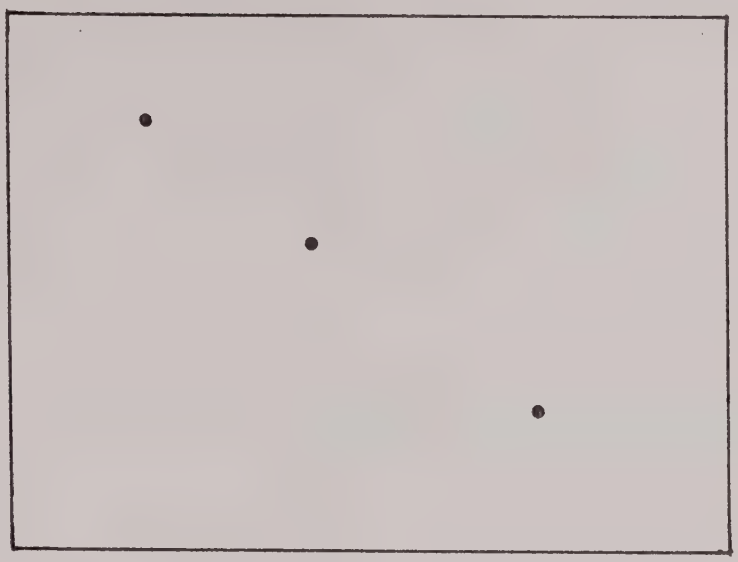


Figure 11d
Side Drilled Holes

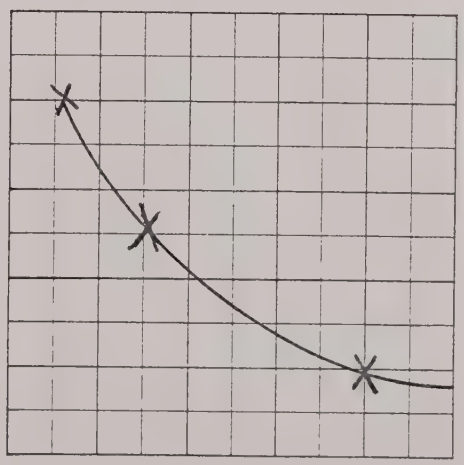


Figure 11e
D.A.C. Curve

Test Procedure

Increase the gain from reference level to an appropriate scanning level. Then, scan the test material with the probe and obtain maximum amplitude echoes from any reflectors that are found. Reflectors whose peak amplitude exceed the DAC line have a reflecting amplitude greater than the reference reflector and have the potential to be considered rejectable. However, other factors such as type and length of reflector are frequently considered before a reflector is deemed rejectable.

With USL-36 and USL-38 instruments, distance-amplitude correction can be achieved automatically by using the Electronic DAC as described in Section 6.

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